

What is claimed is:

1. A substrate processing apparatus comprising:
  - a processing vessel forming a processing space;
  - 5 a rotatable supporting table for supporting a substrate to be processed in the processing space;
  - a rotation mechanism of the supporting table;
  - a nitrogen radical generation unit, provided at an end portion of the processing vessel at a first side of the supporting table, for forming nitrogen radicals by a high  
10 frequency plasma and supplying the nitrogen radicals into the processing space, the nitrogen radicals flowing along a surface of the substrate to be processed from the first side to a second side, the second side facing the first side with  
15 the substrate to be processed placed therebetween;
  - an oxygen radical generation unit, provided at the end portion at the first side, for forming oxygen radicals by a high frequency plasma and supplying the oxygen radicals into the processing space, the oxygen radicals flowing along the  
20 surface of the substrate to be processed from the first side to the second side; and
  - a gas exhaust path, provided at an end portion at the second side, to exhaust the processing space,
  - wherein the nitrogen radicals and the oxygen radicals  
25 flow towards the gas exhaust path from the nitrogen radical generation unit and the oxygen radical generation unit while

forming a nitrogen radical flow path and an oxygen radical flow path along the surface of the substrate to be processed, respectively.

5     2.     The substrate processing apparatus of claim 1, wherein  
the nitrogen radical generation unit includes a first gas  
passageway and a first high frequency plasma generation unit  
formed at a part of the first gas passageway to excite a  
nitrogen gas passing therethrough into a plasma; and the  
10    oxygen radical generation unit includes a second gas  
passageway and a second high frequency plasma generation  
unit formed at a part of the second gas passageway to excite  
an oxygen gas passing therethrough into a plasma,

          wherein the first and the second gas passageway are in  
15   communication with the processing space.

3.     The substrate processing apparatus of claim 1, wherein  
the nitrogen radical flow path and the oxygen radical flow  
path are substantially parallel to each other.

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4.     The substrate processing apparatus of claim 1, wherein  
the nitrogen radical generation unit is installed to allow  
the distance between a center of the nitrogen radical flow  
path and that of the substrate to be processed to be 40 mm  
25   or less.

5. The substrate processing apparatus of claim 1, wherein the oxygen radical generation unit is installed to allow the distance between a center of the oxygen radical flow path and that of the substrate to be processed to be 40 mm or less.
6. The substrate processing apparatus of claim 1, wherein a center of the nitrogen radical flow path intersects with that of the oxygen radical flow path substantially at a center of the substrate to be processed.
7. The substrate processing apparatus of claim 1, wherein there is provided a flow adjusting plate interfering with the nitrogen radical flow path to change a direction thereof.
8. The substrate processing apparatus of claim 1, wherein there is provided a flow adjusting plate interfering with the oxygen radical flow path to change a direction thereof.
9. A substrate processing method for use in a substrate processing apparatus, which includes a processing vessel forming a processing space and having a supporting table for supporting a substrate to be processed in the processing space; a first radical generation unit for supplying first radicals into the processing vessel, the first radicals flowing along a surface of the substrate to be processed

from a first side of the processing vessel to a second side that faces the first side with the substrate to be processed placed therebetween; and a second radical generation unit for supplying second radicals into the processing space, the  
5 second radicals flowing along the surface of the substrate to be processed from the first side to the second side, the method comprising:

a first process of processing the substrate to be processed by supplying the first radicals from the first  
10 radical generation unit into the processing space while introducing a purge gas purging the second radical generation unit into the processing space from the second radical generation unit; and

a second process of processing the substrate to be  
15 processed by introducing the second radicals from the second radical generation unit into the processing space.

10. The substrate processing method of claim 9, wherein the substrate to be processed is a silicon substrate; and,  
20 in the first process, the surface of the silicon substrate is oxidized by the first radicals to form an oxide film, the first radicals being oxygen radicals.

11. The substrate processing method of claim 10, wherein,  
25 in the second process, a surface of the oxide film is nitrided by the second radicals to form an oxynitride film,

the second radicals being nitrogen radicals.

12. The substrate processing method of claim 9, wherein  
the first and the second radicals are supplied by being  
5 carried by a gas stream flowing from the first side to the  
second side along the surface of the substrate to be  
processed, and exhausted at the second side.

13. The substrate processing method of claim 9, wherein  
10 the first radical generation unit forms oxygen radicals by a  
high frequency plasma.

14. The substrate processing method of claim 9, wherein  
the first radical generation unit includes an ultraviolet  
15 light source forming oxygen radicals.

15. The substrate processing method of claim 9, wherein  
the second radical generation unit forms nitrogen radicals  
by a high frequency plasma.

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16. The substrate processing method of claim 15, wherein  
the second radical generation unit includes a gas passageway,  
and a high frequency plasma generation unit formed at a part  
of the gas passageway to excite a nitrogen gas passing  
25 therethrough into a plasma.

17. The substrate processing method of claim 16, wherein the purge gas is supplied through the gas passageway.
18. The substrate processing method of claim 9, wherein  
5 the purge gas is an inactive gas.
19. A substrate processing method comprising:  
a first process for performing a first processing on a substrate to be processed in a processing vessel;  
10 a second process for unloading the substrate from the processing vessel;  
a third process for performing an oxygen removal process from the processing vessel;  
a fourth process for loading the substrate into the  
15 processing vessel; and  
a fifth process for performing a second processing on the substrate.
20. The substrate processing method of claim 19, wherein,  
20 in the oxygen removal process, a processing gas is excited into a plasma and introduced into the processing vessel, and the processing gas is exhausted from the processing vessel.
21. The substrate processing method of claim 20, wherein  
25 the processing gas is an inactive gas.

22. The substrate processing method of claim 19, wherein the substrate to be processed is a silicon substrate, and the first processing is an oxidation process for oxidizing a surface of the silicon substrate to form an oxide film.

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23. The substrate processing method of claim 22, wherein the second processing is a nitridation process for nitriding the oxide film to form an oxynitride film.

10 24. The substrate processing method of claim 23, wherein the processing vessel has an oxygen radical generation unit and a nitrogen radical generation unit; the oxidation process is carried out by oxygen radicals formed by the oxygen radical generation unit; and the nitridation process  
15 is performed by nitrogen radicals formed by the nitrogen radical generation unit.

25. The substrate processing method of claim 20, wherein the plasma excitation is carried out in the nitrogen radical  
20 generation unit, and a processing gas excited into a plasma is introduced from the nitrogen radical generation unit into the processing vessel.

26. The substrate processing method of claim 24, wherein  
25 the oxygen radicals and the nitrogen radicals flow along the substrate to be processed, and are exhausted from a gas

exhaust port installed at an opposite side to the oxygen radical generation unit and the nitrogen radical generation unit along a diametrical direction of the substrate to be processed, which is mounted in the processing vessel.

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27. The substrate processing method of claim 19, wherein the processing vessel is connected to a cluster substrate processing system in which a plurality of substrate processing apparatus are connected to a transfer chamber.

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28. The substrate processing method of claim 27, wherein the substrate is transferred from the processing vessel to the substrate transfer chamber in the second processing.

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29. The substrate processing method of claim 27, wherein the substrate is mounted in the substrate transfer chamber in the third processing.

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30. The substrate processing method of claim 27, wherein the substrate is transferred from the transfer chamber to the substrate processing vessel in the fourth processing.